THE UNIVERSITY OF ALBERTA

A STATISTICAL ANALYSIS OF CATTLE PRICES ON TERMINAL AND AUCTION MARKETS IN ALBERTA

by

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "A Statistical Analysis of Cattle Prices on Terminal and Auction Markets in Alberta," submitted by Curtis E. McIntosh in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

This thesis is an exercise in the use of dummy variables in regression analysis. The technique was used to quantify and analyze the effects of certain qualitative or categorical variables on cattle prices at terminal and auction markets in Alberta.

Price variation is a subject that demands the attention of many individuals connected with cattle production and marketing in Alberta. The study sought to identify and measure the effects of some pertinent variables in the marketing system. Cattle prices on different markets -- terminals and auctions -- were compared. A comparison was also made of pricing in three different areas: namely, the Crande Prairie region, Central Alberta, and Southern Alberta.

Among the variables hypothesized as affecting cattle prices, class, grade, and weight were the most important, both for feeder and slaughter cattle. Low prices were associated with the presence of horns and also a full condition.

The results of the analysis pointed out some important implications regarding the production and marketing of cattle in Alberta. Producers stand to gain by paying attention to fill, dehorning, and castration of male calves. An official grading system for feeder cattle should be instituted and the grading system for slaughter cattle reviewed.

ACKNOWLEDGEMENTS

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I would also like to thank Dr. A. A. Warrack, Dr. W. E. Phillips, Dr. L. P. Apedaile and Mr. W. Thoman for their contributions to the study. Many thanks are due to the typists who worked through several drafts of the manuscript, and to Mrs. M. E. Richeson for her literary criticisms.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The Importance of the Beef Industry

Beef is one of the two most important red meats consumed by Canadians and tends to be preferred above pork in the Canadian diet.[1] A comparison of the pre-World War II level of red meat consumption and that of 1965 showed an increase from 1.5 billion pounds to 2.7 billion pounds per annum. Per capita consumption of red meat rose from 118.1 pounds in 1935-39 to 182.3 pounds in 1965. For the same period per capita beef consumption was 54.7 pounds and 78.7 pounds, respectively, while pork was 39.8 pounds and 49.2 pounds.[2]

The production of beef cattle has been of special importance in the Canadian economy. There has also been a significant increase in the relative importance of beef cattle in Canada, both from the increase in farm income accruing from sales of cattle and calves and from a rising proportion of income from cattle relative to other farm enterprises.[3] In 1956 sales of cattle and calves realized $424.7 million, which constituted 16.9 percent of the total gross farm income.

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[1]L. E. Drayton, "Red Meat Consumption in Canada," The Economic Annalist (October, 1959), 103-104.

[2]Canada Dominion Bureau of Statistics, Canada Yearbook (Ottawa: Queen's Printer and Controller of Stationery, 1957-1958, 1967), 449-454, 500-503.

[3]V. W. Yorgason, "Beef and Beef Cattle in Canada's Farm Economy," The Economic Annalist (June-August, 1965), 40.

In 1965 similar sales valued $772.7 million and accounted for 20.3 percent of the total gross farm income.[1]

Approximately 80 percent of the beef cattle are produced in Western Canada, the highest concentration being in Alberta and Saskatchewan. Alberta is a surplus-producing area and in 1966 exported about 74 percent of its meat production primarily to the Eastern provinces and British Columbia. In 1966, 75 percent of the farms in Alberta raised beef. Fifty-two percent of the total population of 3.36 million head were on farms reporting between 18 and 77 head per farm.[2]

Objectives

The objectives of this study were (1) to quantify certain qualitative or categorical variables that were hypothesized to affect cattle prices, (2) to develop regression equations explaining variation in cattle prices, (3) to differentiate the markets for feeder and slaughter cattle, and (4) to compare cattle pricing on auction and terminal markets and between different areas in the Province of Alberta.

Hypotheses

It was hypothesized that price was a function of the following independent variables:

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[1] Canada D.B.S., *op. cit.*

[2] Compiled from statistics from the Agricultural Economics Division, Alberta Department of Agriculture, Edmonton.

1. Type
2. Class
3. Weight
4. Buyer
5. Condition
6. Grade
7. Horns
8. Type of Market
9. Geographic area.

Subsidiary hypotheses tested included price and one or more of the independent variables.

Importance of the Study

Paralleling the increasing importance of the cattle and beef industry has been the development of a complex marketing system. In this economic system based on the philosophy of competition, the pricing of livestock and livestock products constitutes a subject of increasing concern. This study sought to determine and assess the importance of certain factors affecting cattle prices. The findings of this study have particular relevance in assessing the performance of the cattle marketing system in Alberta and might provide a basis for policy formulation. The findings should also be useful to farmers, ranchers, and feedlot operators in the decision-making process.

Sources of Data and the Procedural Technique

The data used in this study were obtained chiefly from research carried out by the Department of Agricultural Economics of The University of Alberta in 1964. Other sources of information included references and livestock reports published by the Dominion Bureau of Statistics and personal interviews.

Observations were made on two terminal markets -- Edmonton and Calgary -- and twelve selected auction markets. The markets covered

three geographic regions -- the Grande Prairie region in the North, Central Alberta, and Southern Alberta. In the nine weeks of the study 4,462 observations involving 7,915 cattle were made. Data from the terminal markets were collected on the Monday of each week, while those from the auction markets were taken on the following days. Adjustments were made for price variations during the week to standardize data to Monday terminal prices. These adjustments were made by increasing or decreasing observed prices by the full amount of a fall or a rise in the average prices quoted for the terminal markets. All observations were made by a single experienced livestock buyer. The data were analyzed through the use of dummy variables in regression analysis.

Limitations of the Study

The study was done during a relatively short period, which did not allow for seasonal price variation. A longer time period, however, would have added significantly to the high costs involved. The study was not designed to develop a model for predicting cattle prices. The observations involved subjective estimates. To the extent that these were inaccurate, the chances of obtaining meaningful results were reduced. Other limitations arising from the weaknesses of the analytic technique are discussed in the following chapter.

Organization of the Thesis

A discussion of the basic concepts and considerations underlying the analytic technique follows in the next chapter. The chapter

also includes a review of the literature and the strengths and weaknesses of the technique. In Chapter 3 the cattle marketing system in Alberta is described. Chapter 4 outlines the results of the analysis, and Chapter 5 is a presentation of the implications of the results, conclusions, and recommendations.

CHAPTER 2

THE ANALYTIC TECHNIQUE

Dummy Variables

The analytic technique used in the study may be described as the general linear regression model incorporating dummy variables in the regression equation. The familiar use of the multiple linear regression model has been to estimate the relationship between variables measured conventionally on a numerical scale. Thus prices, incomes, or weights are measured by cardinal numbers and used in the regression analysis. However, many analytic problems involve variables that are not usually measured on a numerical scale. The incorporation of dummy variables is a simple and useful method of introducing into a regression analysis information contained in variables that are not conventionally measured on a numerical scale.[1]

This technique is a means of quantifying qualitative or categorical variables and thus makes possible the least squares analysis of data with these variables. It is particularly useful in the analysis of problems in which such variables as race, religion, sex, marital status, education or occupation are present.[2]

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[1] D. B. Suits, "Use of Dummy Variables in Regression Equations," *Journal of the American Statistical Association*, LII (1957), 548.

[2] *Ibid.*

The use of dummy variables allows the transformation of an analysis of variance problem to a least squares problem. In the analysis of variance model a particular quantity is measured on different observed individuals, each belonging to a class defined by one or more factors. The model stipulates that the value measured is a random variable whose expected value depends only on the class to which the individual considered belongs.[1]

The essence of this technique is to assign a dummy variable to each class of a characteristic except one. It is called a dummy variable because it takes the value one if the individual belongs to that category or zero if he does not.[2] Other types of dummy variables do exist however. Examples include: a series of positive integers; plus one or minus one; a sequence of positive and negative integers which sum to zero such as +1, 0, and -1.[3] Dummy variables may be used as dependent or independent variables in the regression analysis.

The General Linear Model

The general linear model has been dealt with in several text-

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[1] E. Malinvaud, Statistical Methods of Econometrics (Chicago: Rand McNally and Company, 1966) pp. 227-228.

[2] A. A. Warrack, "Dummy (Independent)Variables in Regression Analysis," Unpublished Paper, 1966, p. 1.

[3] J. N. Morgan and J. A. Sonquist, "Problems in the Analysis of Survey Data, and a Proposal," Journal of the American Statistical Association, LVIII (1963), p. 422.

books. This overview of the model is intended to provide a basis for the discussion of the use of dummy variables. Most of the information contained in the overview was gleaned from the following authors: A. S. Goldberger, J. Johnston, and E. Malinvaud.[1]

The Model

Suppose that there exists a dependent variable y_1 (i = 1, 2, ..., n) and k-1 independent variables x_j (j = 2, 3,..., k). Let Y denote the vector of the dependent variable and X that of the independent variables.

The model stipulates that the dependent variable is determined by the independent variables simultaneously, according to the equation:

$$Y = XB + E, \tag{1}$$

where B is a vector of k as yet unknown parameters, and E is an unobservable random n-vector. That is to say each y_i is determined by the x_j according to the equation:

$$y_i = b_1 + b_2 x_{2i} + \ldots + b_k x_{ki} + e_i \qquad i = 1, 2, \ldots, n \tag{2}$$

The Assumptions

1. The basic assumption of the model is that there exists a linear relationship between the dependent variable y_i and the independent variables x_j. The variable y_i is random and satisfies equation (2)

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[1] A. S. Goldberger, *Econometric Theory* (New York: John Wiley and Sons, 1964); J. Johnston, *Econometric Methods* (New York: McGraw-Hill, 1963); E. Malinvaud, *op. cit.*

above, where $b_1, \ldots, b_k$ are numerical coefficients, and e_i is an observable random variable with an expected value of zero for all x_j. The random variable e is known as the error term.

The equation specifies that the observable quantities x_j and the unobservable e_i represent the causes that determine the values of the quantity y_i. The e_i accounts for the effect of all unidentifiable factors.[1]

The variables y and x are observed without error. That is, there are no appreciable differences between the observed values and the true values.

The condition that the expected value of e_i equals zero, regardless of what values x takes, is necessary for the solution of the model. In practice the e_i takes plus or minus values the expected sum of which is constrained to zero. The condition does not hold if the e_i is correlated with the x_i.[2]

2. The random error e is distributed independently of the number of observations and the explanatory variables, and it has a variance. This assumption supports the first assumption that the mean of the error terms is zero regardless of the values of x. It states further that all the error terms have the same distribution -- a condition known as homoscedasticity -- and a variance.

3. The error terms relating to different observations are mutually independent. This assumption is of particular importance

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[1] *Ibid.*, p. 172.

[2] *Ibid.*, p. 76.

when different time periods are involved. It specifies that there is no correlation between error e_t and e_{t+1} resulting from observations on x_t and x_{t+1}. This condition is described as the independence of the error terms.

4. The error terms have a normal distribution. This assumption is not crucial since homoscedasticity, or the existence of a variance, is sufficient for obtaining solutions to many problems.

5. The independent variables are a fixed set of numbers with a mean and variance. By repeated sampling, the only source of variation in y depends on x and e. The X matrix has a rank $k < n$, and there are no exact linear relations between the x. This means that the number of observations is greater than the number of parameters. This assumption is crucial in the estimation procedure.

The crucial assumptions for the solution of the general linear model may be stated, according to Johnston[1], as follows:

$$E(e) = 0 \tag{3}$$

$$E(ee') = \sigma I_n \tag{4}$$

$$X \text{ is a set of fixed numbers} \tag{5}$$

$$X \text{ has rank } k < n \tag{6}$$

<u>The Estimation Procedure</u>

The general linear model denoted by equation (1) above contains the B coefficients and the parameters of the error terms, which are unknown. The problem is to derive estimates for these unknowns. The aforementioned texts describe the derivations in detail. An axiomatic approach here would suffice.

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[1] J. Johnston, <u>op. cit.</u>, p. 107.

Least Squares Estimators -- The method of least squares yields the best linear unbiased estimates for the B coefficients. Let $B = (B_1, B_2, \ldots, B_k)$, the expected values of the coefficients denoted by B in equation (1). The expected B values are obtained by solving the matrix equation:

$$Y = XB + E, \tag{7}$$

for the vector B that minimizes e'e, the sum of the squared residuals. The following results are obtained.[1] The best linear unbiased estimates of B are given by the equations:

$$B = (X'X)^{-1}X'Y$$

and $$B_1 = \overline{Y} - B_2\overline{X}_2 - \ldots - B_k\,\overline{X}_k,$$

whose covariance is given by

$$\mathrm{var}(B) = \sigma\ (X'X)^{-1}.$$

The unbiased estimator of σ^2 is

$$s^2 = e'e/n-k.$$

The coefficient of multiple correlation is given by

$$R^2 = B'X'Y/Y'Y.$$

which is the sum of squares due to the linear influence of the explanatory variables divided by the total sum of squares.

Significance Tests and Confidence Intervals -- The t and F statistic are two tests of significance frequently employed. The test that $B_2 = \ldots = B_k = 0$ is based on

$$F = \frac{R^2/(k-1)}{(1-R^2)/(n-k)}$$

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[1] Ibid., p. 134-135.

where k-1 and n-k denote degrees of freedom. The test that $B_i = 0$, $i = 2, 3, \ldots, k$ is based on

$$t = \frac{\hat{B}_i - B_i}{\hat{S}\sqrt{a_{ii}}},$$

with n-k degrees of freedom and where a_{ii} is the element corresponding to X_i in the principal diagonal of $(X'X)^{-1}$.

A 100 (1-e) percent confidence interval for B_i $(i = 2, 3, \ldots, k)$ is

$$B_i \pm t_{e/2}\,\hat{s}\sqrt{a_{ii}}.$$

The t-statistic may be used to test the hypothesis $c'B = r_o$, where c is a k-1 column matrix, according to the equation:

$$t = \frac{c'\hat{B} - r_o}{\hat{s}\sqrt{c'(X'X)^{-1}c}},$$

with n-k degrees of freedom. The 100(1-e) percent interval for $c'B$ is

$$c'\hat{B} \pm t_{e/2}\hat{s}\sqrt{c'(X'X)^{-1}c}.$$

Incorporation of Dummy Variables

Application

For the successful application of dummy variables in regression equations two conditions must be met. First, the original data must be logically divisible into mutually exclusive classes or groups. Secondly, the effect of class differences must be to change the intercept of the regression equations, leaving the slope coefficients

unchanged. However, this condition may be modified to allow slope changes.[1]

Dummy Variable Forms

Three forms of dummy variable models exist: (1) A step-function in which all the independent variables are dummies and consideration is given solely to intercept changes; (2) A covariance model which allows for intercept changes, slope being held constant; (3) A covariance model which allows for slope changes, but with a fixed intercept. The covariance models have both quantitative and dummy independent variables.[2]

The Dummy Variable Model

To illustrate the use of dummy variables in regression analysis one can specify a relationship of the type:

$Y = f(X,Z)$,

where Y refers to prices; X refers to three geographic regions -- North, Central, and South; and Z denotes two type of cattle -- feeder and slaughter. This model and subsequent analysis are for the most part taken from Melichar's paper.[3]

Five dummy variables are used to code the observations on the individuals. The value 1 or 0 is assigned to each category depending on whether the individual belongs to that category or not. The coding is in Table 1.

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[1] W. G. Tomek, "Using Zero-One Variables with Time Series Data in Regression Equations," Journal of Farm Economics, XL (1963), 814.

[2] Ibid., 814-822; E. Malinvaud, op. cit., 223.

[3] E. Melichar, "Least Squares Analysis of Economic Survey Data," A Paper Presented at the Annual Meeting of the American Statistical Association, Philadelphia, Pennsylvania, September 11, 1965.

Table 1

CODING OF OBSERVATIONS WITH DUMMY VARIABLES

Dependent Variable	Independent Variables				
Y	X_1	X_2	X_3	Z_1	Z_2
y_1	1	0	0	1	0
y_2	0	1	0	1	0
y_3	0	0	1	1	0
y_4	1	0	0	0	1
y_5	0	1	0	0	1
y_6	0	0	1	0	1

The regression equation to be estimated is of the familiar linear regression form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4Z_1 + b_5Z_2, \tag{8}$$

in which Y refers to prices, X_1, X_2, and X_3 represent the three geographic regions North, Central, and South, respectively; and Z_1 and Z_2 the two types -- feeder and slaughter cattle respectively. The intercept term is denoted by a.

Estimation

A regression equation of this type is indeterminate, since there are more coefficients than there are independent normal equations. Solution of such an equation, therefore, requires the imposition of additional constraints on the parameters.[1]

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[1]D. B. Suits, _op. cit._, p. 548.

Three types of constraints have been found to be particularly useful. These involve constraining to zero (a) one of the coefficients for each of the independent classes, (b) the constant term, or (c) the weighted sum of the coefficients for each of the independent classes. Constraints (a) and (b) were suggested by D. B. Suits and (a) and (c) were suggested by E. Melichar. W. G. Tomek discussed all three.[1]

If constraint (a) is used, one may specify:

$$b_3 = b_5 = 0,$$

for the above example. The equation now becomes:

$$Y = a' + b_1'X_1 + b_2'X_2 + b_4'Z_1.$$

The b' coefficients of this new equation estimated the net effect on Y due to membership in that class, as compared with membership in the class whose coefficient is constrained to zero. For example, b_1 estimates the effect on price that was associated with a steer, sold in the North rather than in the South; and b_4 measures the effect of its being a feeder steer rather than a slaughter steer. Similar coefficients could be obtained for b_3 and b_5 by setting $b_2 = b_4 = 0$. Under this constraint the effect of the omitted variables are embodied in the intercept term, a'. This is a simple concept but interpretation becomes difficult when the model includes several groups of variables.[2]

When the second constraint is used, the effect is to convert the original equation into the homogeneous form:

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[1]Ibid.; E. Melichar, op. cit.; W. G. Tomek, op. cit.

[2]E. Melichar, op. cit., p. 4.

$$Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4Z_1 + B_5Z_2, \qquad (10)$$

whose coefficients can now be estimated. In this case the b coefficients measure deviations from the origin.[1]

The last type of constraint becomes somewhat more involved. The constraints in the example would be:

$$x_1b_1^* + x_2b_2^* + x_3b_3^* = 0, \qquad (11)$$

and $$z_4b_4^* + z_5b_5^* = 0. \qquad (12)$$

The small x's and z's are the number of steers observed in the corresponding classes designated by the large X's and Z's. Thus x, is the number of steers belonging to the class X_1 (North).

One can now solve (4) and (5) for one of the coefficients. For example:

$$b_3^* = (-x_1b_1^* - x_2b_2^*)/x_3, \qquad (13)$$

and $$b_5^* = -z_4b_4^*/z_5. \qquad (14)$$

Substituting these values in equation (1) and collecting terms, one has:

$$Y = a^* + b_1^*(X_1 - \frac{x_1}{x_3}X_3) + b_2^*(X_2 - \frac{x_2}{x_3}X_3)$$

$$+ b_4^*(Z_1 - \frac{z_1}{z_2}Z_2) \qquad (15)$$

This equation may be rewritten using a new set of variables, thus:

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[1]D. B. Suits, op. cit., p. 549.

$$Y = a^* + b_1^* X_1^* + b_2^* X_2^* + b_4^* Z_1^* \qquad (16)$$

where:

$$X_1^* = X_1 - \frac{x_1}{x_3} X_3,$$

$$X_1^* = X_2 - \frac{x_2}{x_3} X_3,$$

and $$Z_1^* = Z_1 - \frac{z_1}{z_2} Z_2.$$

The values for these variables are calculated from the original observations in Table 1 and are shown in Table 2. When the estimates in this equation are found, they are substituted in (4) and (5) to obtain values for b_3^* and b_5^*. The independent variables in equation (16) each have a mean of zero, thus making the mean of the dependent variable always equal to the constant term (a^*). The effect of the coefficients is interpreted as the net deviation from the mean of the dependent variable.

By constraining the sum of the b coefficients to zero, the zero-one dummy variable assignment changes to 1 and -1 for a dichotomy and 1, 0, and -1 for a trichotomy. These new dummies can be used directly in quantifying categorical variables instead of the zero-one dummies. Thus in the problem one may have assigned dummies as follows:

X_1 = 1 if the individual was observed in the North
= 0 if the individual was not observed in the North

X_2 = 1 if the individual was observed in the Central Region
= 0 if the individual was not observed in the Central Region

If the individual was observed in the South, then X_1 and X_2 take values of -1, X_3 being the omitted variable.

Z_1 = 1 if the animal was a feeder
= -1 if the animal was a slaughter, Z_2 being the omitted variable.

With this type of assignment estimates are obtained for b_1, b_2 and b_4. The other coefficients are obtained as follows:

$b_3 = -(b_1 + b_2)$ and $b_5 = -b_4$.

Table 2

TRANSFORMATION OF CODED OBSERVATIONS

Dependent Variables	Independent Variables		
Y	X_1^*	X_2^*	Z_1^*
y_1	1	0	1
y_2	0	1	1
y_3	$-\frac{x_1}{x_3}$	$-\frac{x_2}{x_3}$	1
y_4	1	0	$-\frac{z_1}{z_2}$
y_5	0	1	$-\frac{z_1}{z_2}$
y_6	$-\frac{x_1}{x_3}$	$-\frac{x_2}{x_3}$	$-\frac{z_1}{z_2}$

Interpretation of the results are again from the intercept term which is the average for all observations.

The different types of constraints yield identical estimates on Y, though the direct interpretation of the three forms differ.

Thus under constraint (a), the interpretation of the b coefficient is with reference to the class whose coefficient is constrained to zero. Constraint (b) allows measurements from the origin, while constraint (c) measures deviations from the mean of the dependent variable. It is possible to transform coefficients estimated under one constraint into the value that would be obtained under another constraint. The results are the same regardless of type of constraint.[1]

Alternative Forms

The model just described is of the step-function type, where all the independent variables are dummies and only intercept changes are examined. The covariance models merit some comments.

The covariance model allowing for intercept changes while slope is held constant may be illustrated as follows:

$$Y = a + b_1X_1 + b_2R_1 + b_2R_2 + u, \tag{17}$$

where Y denotes wages, X is a quantitative variable representing hours of work, and R represents work shifts comprising two classes -- day and night. Assuming that slope is constant, the actual regression equations for the two work shifts may be:

Day Shift : $Y = 5 + .45X_1 = A$

Night Shift: $Y = 10 + .45X_1 = B$

This situation may be shown pictorially as in Figure Ia. The difference between the work shifts is interpreted as the distance between the regression lines (A) and (B).

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[1]D. B. Suits, op. cit., p. 549; E. Melichar, op. cit., p. 7.

The covariance model allowing for slope changes could be illustrated if the results of the example were:

Day Shift : $Y = 5 + .45X_1 = A$

Night Shift: $Y = 10 + .60X_2 = C$

The results are shown graphically in Figure Ib. Here not only is there

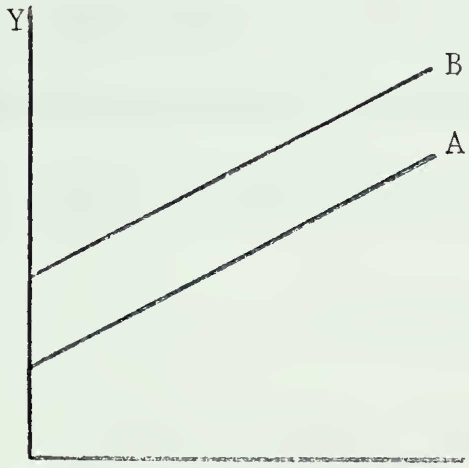

Figure Ia

Regression Lines for Day and Night Shifts Illustrating Constant Slope

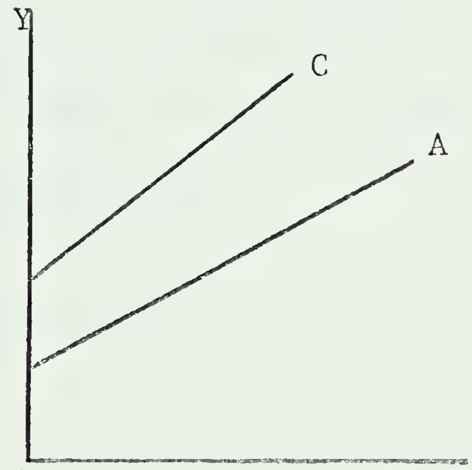

Figure Ib

Regression Lines for Day and Night Shifts Illustrating Slope Changes

a difference in the intercept terms for the two work shifts, possibly brought out by the use of dummy variables, but the slopes differ. This suggests the technique may be useful if slope coefficients are ignored. The difference in slope coefficients is assumed to result from factors other than the dummy independent variables.[1]

Tomek suggested that when slopes differ among classes, the intercept differences were only meaningful at the point of means of all observations of the non-dummy independent variable. In his opinion, the covariance model allowing for slope and intercept changes had limited application for most economic problems and that in any case,

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[1] W. G. Tomek, *op. cit.*, p. 817.

the model was subject to misuse and misinterpretation.[1]

These basic models may be extended and modified to solve a host of economic problems. One such application is in analyzing slope changes (kinks) due to time series effects (in an otherwise linear function). The fundamental condition, however, that the classes must be logically and mutually exclusive, must be obtained before dummy variables can be applied successfully. The estimation problems are the same in all three basic dummy variable forms.

A Review of the Assumptions

The assumptions of the general linear model have been discussed. Do they hold when dummy variables are used in regression analysis? The answer is that they do, but there are modifications which may be observed.

From the foregoing discussion two assumptions are subject to modification. First, since intercept changes provide the basis of interpretation for most models, the assumption of linearity between the dependent and the independent variables becomes unnecessary. Secondly, the interaction effects between independent variables are assumed not to exist. This assumption may also be applied to the analysis of problems using dummy variables. It is possible, however, to include in the dummy variable model interaction terms to take care of interaction effects.

Interaction Effects

No factor has a unique effect, isolated from others. Inter-

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[1] *Ibid.*, p. 818.

action is known to exist between economic variables.[1] Interaction refers to a condition where the effect on a dependent variable is determined jointly by two or more explanatory factors. Thus advanced education helps a man more than a woman in a variety of occupations; and it does more for a white man than a Negro.[2]

Interaction differs from intercorrelation. Two explanatory variables, income and education, may be correlated with one another without any interaction, while education and sex may interact. A dummy variable for education in multiple regression analysis takes care of the correlation between income and education without any problem.[3] On the other hand, the net effect of sex and education can be assessed by assigning dummy variables to these factors, and then introducing interaction terms according to the equation:

$$S = a + b_1X + b_2M + b_3I, \qquad (18)$$

where S refers to savings, X denotes education, M represents sex, and I is the interaction term combining education and sex.

The dummy variable assignment is as follows:

X = 1 if the respondent has high level education
  = o if the respondent has low level education

M = 1 if respondent is male
  = 0 if respondent is female

I = XM

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[1] D. B. Suits, _Statistics: An Introduction to Quantitative Economic Research_ (Chicago: Rand McNally and Company, 1963), 111.

[2] J. N. Morgan and J. A. Sonquist, _op. cit._, p. 416.

[3] _Ibid._, p. 418.

The introduction of interaction terms gives greater precision to the results. In addition, strict assumptions about additivity become unnecessary. When, however, interaction terms are introduced, the number of parameters to be estimated increases, thus making for greater complexity of the computer programs and increased costs.

Tests of Significance and Statistical Inference

In general, tests of significance and the inferences drawn when dummy variables are used are the same as in the familiar linear regression model. The importance of the measures of significance and their interpretation give rise to certain problems of statistical inference.

The coefficient of multiple determination is estimated according to the usual formula:

$$R^2 = B'X'Y/Y'Y.$$

The F statistic may be used to test the significance of the net influence of all the variables according to the equation:

$$F = R^2(n - k - 1)/(1-R^2)(k),$$

where R^2 is the coefficient of multiple determination, n is the number of observations, and k the number of independent variables.[1]

The coefficient of partial determination (partial R^2) for a group of variables representing a single factor A may be calculated by the following equation:

$$\text{Partial } R^2 = (R_A^2 - R_B^2)/(1 - R_B^2),$$

where R_A^2 is a coefficient of multiple determination for the regression

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[1] E. Melichar, *op. cit.*, p. 15.

equation which includes factor A, and R_B^2 is the coefficient of multiple determination for the regression equation exclusive of factor A. The partial R^2 for the factor A measures the relative net contribution to the total variation due to that factor.[1] The test of significance of that factor may be found from the equation:

$$F = (R_A^2 - R_B^2)(n - k_1 - k_2 - 1)/(1 - R_A^2)(k_1),$$

in which:

k_1 = the number of independent variables representing factor A,

k_2 = the number of independent variables exclusive of those representing factor A,

n = the number of observations,

R^2 = the coefficient of multiple determination for the regression equation containing $(k_1 + k_2)$ independent variables,

and R_B^2 = the coefficient of multiple determination for the regression equation containing k_2 variables.[2]

From the discussion of the use of dummy variables it is obvious that not only are there inter-group coefficients to be compared, but also intra-group coefficients. The tests of the individual coefficients pose little problem, since these are automatically obtained from suitable computer programs.

E. Melichar suggests that there is little value in testing whether each individual coefficient is significantly different from zero because of the constraints employed in estimation. For example, if the constraint was of the type where one variable was omitted, the test is with reference to the omitted class. Different values would obtain de-

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[1] *Ibid.*, p. 15.

[2] *Ibid.*, p. 17

pending on which class was omitted. Thus one should not conclude that a coefficient is not significant because the null hypothesis was not rejected in one comparison. If the constraint was of the type in which the interpretation was with respect to deviations from the mean, the test of the individual coefficient would be with reference to the overall mean. Such a test may sometimes be useful; but here again, the coefficient should not be regarded as "non-significant" just because it happens to be near this overall mean.[1]

A more meaningful comparison would be that between coefficients within a factor group. It is important, however, that intra-group comparisons should not be made unless the F statistic for the group as a whole is significant.[2]

Advantages and Disadvantages of the Analytic Technique

Advantages

The major advantage of the technique of dummy variables is that one is able to quantify otherwise non-quantifiable or categorical variables and obtain estimates of the net influence. Even certain variables which are conventionally measured on a numerical scale yield more meaningful results when these variables are included in the regression equation in dummy variable form. Thus as Suits points out, the influence of age is frequently U-shaped, and attempts to use chronological age as a linear variable may fail to give significant

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[1] *Ibid.*, p. 19.

[2] *Ibid.*

results.[1]

The usefulness of this technique is further illuminated when one recalls that the assumption of linearity is unnecessary when dummy variables are used in regression analysis. So problems that include the simple and multiple regression, the linear and curvilinear regression, and the analyses of variance and covariance are solved by a unified computing method.[2]

By transforming an analysis of variance problem into a least squares problem, the technique eliminates several computational problems. Not only are there fewer steps in the analysis, but also computer technology favors the analysis of least squares problems, since the inversion of matrices is no longer considered a burden.[3]

Tests of significance depend largely on the number of explanatory variables and the size of the sample. The use of dummy variables increases the number of parameters estimated and thus gives greater precision to tests, since degrees of freedom are gained.[4]

Disadvantages

One obvious disadvantage of this technique is the problem

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[1] D. B. Suits, "Use of Dummy Variables in Regression Equations," Journal of the American Statistical Association, LII (1957), 551.

[2] Jerome C. R. Li, Statistical Inference II (Ann Arbor: Edwards Brothers, Inc., 1964), p. 375.

[3] Ibid.

[4] D. B. Suits, Statistics: An Introduction to Quantitative Economic Research (Chicago: Rand McNally and Company, 1963), p. 136.

of estimation. Computational problems arise because large matrices are sometimes involved. These matrices may be too large for even the largest computers.[1] This problem is likely to be the case when interaction terms are included.

Another disadvantage arises from the nature of the classificatory variables. Two variables, occupation and incidence of unemployment faced by an individual, may not be highly associated; but the occupation code generally includes one or two classes such as farmers and the retired who, by definition, cannot be unemployed at all. Assigning dummy variables to these classes may result in perfect association between a dummy variable representing one of those peculiar (not applicable) groups in one code and another representing something else in another classification (not unemployed). Omission of one of each such pair of dummy variables from the regression equation solves this problem.[2]

Review of the Literature

Reference has been made to several authors during the discussion on the analytic technique. This review is intended to credit some of the more important authors for their contributions and put into perspective the development of the technique. As early as 1930 Ezekiel addressed himself to the problem of measuring the effect of a qualitative independent variable on a numerical dependent variable. He suggest-

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[1] Jerome C. R. Li, _op. cit._, p. 375.

[2] J. N. Morgan and J. A. Sonquist, _op. cit._, p. 422.

ed that the regression relation might be determined by grouping the observations according to classes of the qualitative factor and calculating the average value of the dependent factor for each group. The intensity of the relationship could be estimated by measures of regression and simple correlation. This method of dealing with the qualitative independent variable in multiple regression analysis was essentially an adaptation of the analysis of variance concepts.[1]

Klein attempted to estimate savings equations from sample survey data combining economic, demographic, and attitudinal variables. Equations were estimated for a group of home-owners and renters separately and then simultaneously by the use of a dummy home-ownership variable. The dummy variable H introduced in the equation took the value $H = 1$ if the spending unit was a home-owner, the value $H = 0$ if the spending unit was a renter.[2]

By the late fifties and early sixties many studies employing this analytic technique had been published. Texts and articles in the field of econometrics gave some attention to the theoretical considerations and practical applications of dummy variables in regression analysis.

Lansing and Blood used zero-one variables or a series of positive integers to analyze what factors determined the probability

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[1]M. Ezekiel and K. A. Fox, Methods of Correlation and Regression Analysis (New York: John Wiley and Sons Inc., 1963), pp. 378, 411.

[2]L. R. Klein, "Estimation Paterns of Savings Behaviour from Sample Survey Data," Econometrica, XIX (1951), 440.

that an individual will take at least one air trip.[1] The authors pointed out that the assignment of the numerical values were arbitrary and had reservations on the accuracy of the results. Melichar concluded that this technique was seldom satisfactory, since its users could not ascertain how much the predetermined scale differed from the scale that would have been indicated as optimum by the data itself.[2]

Adams used the same type of dummies to measure the influence of a set of factors on income variation.[3] The factors he found significant in explaining income variation were age, education, occupation, number of months worked per annum, geographic region, and city size.

Hill assigned a set of zero-one dummies to estimate the net effects of several demographic variables on income levels.[4]

He represented the regression model thus:

$$Y = M + O_i + A_j + R_k + T_l + I_m + (OA)_{ij} + (OR)_{ik} + (OT)_{il} + e,$$

in which:

M = general parameter

O_i = occupational classes $\qquad i = 1, 2, \ldots, 9.$

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[1] J. B. Lansing and D. M. Blood, "A Cross-Section Analysis of Non-Business Air Travel," Journal of the American Statistical Association, LIII (1958), 928-947.

[2] E. Melichar, op. cit., p. 1.

[3] F. G. Adams, "The Size of Individual Incomes: Socio-Economic Variables and Chance Variation," The Review of Economics and Statistics, XL (1958), 390-398.

[4] T. P. Hill, "An Analysis of the Distribution of Wages and Salaries in Great Britain," Econometrica, XXVII (1959), 355-381.

A_j = age groups $\qquad j = 1, 2, \ldots, 6.$

R_k = geographic regions $\qquad k = 1, 2, 3, 4.$

T_l = town size $\qquad l = 1, 2, 3.$

I_m = industry $\qquad m = 1, 2, \ldots, 10.$

$(OA)_{ij}$ = joint classification of occupation and age

$i = 1, 2, 3.$
$j = 1, 2, \ldots, 6.$

$(OR)_{ik}$ = joint classification of occupation and region

$i = 1$
$k = 1, 2, 3, 4.$

$(OT)_{il}$ = joint classification of occupation and town size

$i = 1$
$l = 1, 2, 3.$

The dummy variable assignment for the various factors were of the general form:

$$b_1 O_1 + b_2 O_2 + \ldots + b_8 O_8$$

where O_1 = 1 if the respondent is in class i
= 0 if otherwise

Also included in the regression model were a limited number of preselected interaction terms for joint classifications of occupation and age, region, or town size, respectively. Hill paid particular attention to the question of the computational problems involved.

Perhaps the most extensive use made of dummy variables in regression analysis was that by Orcutt et. al.[1] The authors used the technique in exploring microanalysis and simulation of the United States socioeconomic system. The study brought out the usefulness and

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[1]G. H. Orcutt, et. al., Microanalysis of Socioeconomic Systems: A Simulation Study, (New York: Harper and Brothers, 1961).

effectiveness of the technique. Several pages were devoted to the theoretical considerations underlying the technique and the mechanics of use.

Tomek discussed the application of zero-one variables with time series data in regression equations.[1] His main concern was (a) determining the appropriate circumstances for the use of zero-one variables, (b) the mechanics of use, and (c) the interpretation of the results. He also commented on the effectiveness of the technique in models in which allowances must be made for slope changes.

The most quoted reference on the use of dummy variables in regression analysis is probably Suits.[2] In his article he put forward the basic concepts of the technique, described the estimation procedure, and commented on the use of interaction terms. Morgan and Sonquist[3] in their paper on the problems in the analysis of survey data discussed the effectiveness of the technique of dummy variables. They emphasized its importance in solving the problems of interaction effects and intercorrelation.

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[1]W. G. Tomek, _op_. _cit_., pp. 415-434.

[2]D. B. Suits, "Use of Dummy Variables in Regression Equations," _Journal of the American Statistical Association_, LII (1957), 548-551.

[3]J. N. Morgan and J. A. Sonquist, _op_. _cit_., pp. 415-434.

CHAPTER 3

THE CATTLE MARKETING SYSTEM IN ALBERTA

The market for cattle in Alberta has no provincial boundaries. In fact, it is international in scope.[1] Delineation of this segment for discussion is perforce arbitrary and is done for convenience and simplicity. The cattle market is a part of a more complex marketing system -- the Alberta Livestock Marketing System -- a system which is shared by cattle, hogs, and lambs.

Marketing Agencies and Channels of Distribution

Many individuals and institutions constitute a marketing complex for initiating and effecting the flow of cattle from producers to packing plants or for export. These agencies as they are called may be: producers, terminal markets, livestock auctions, commission firms, shippers and shipping associations, dealers, order buyers, truckers, and meat packing plants. Some cattle are sold directly to packing plants, but generally there are indirect flows through one or more of the above agencies.

The essence of marketing is the performance of the exchange function or the transfer of ownership and the setting of the exchange price.[2] The course taken in the transfer of title to a product is

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[1]A. W. Wood, "Beef Consumption Trends and Distribution Patterns," Unpublished paper presented at Farm Conference Week, University of Manitoba, February 26, 1963.

[2]T. N. Beckman and W. R. Davidson, Marketing (New York: The Ronald Press Company, 1967), p. 230.

referred to as the channel of distribution. The individuals, firms, or associations between the producer and the packing plant take title or assist directly in the transfer of the product. They receive payment for their services, plus profits or minus losses that are concomitant with entrepreneurial functions.[1]

Agencies

Producers

There are three important groups of cattle producers in Alberta; namely, ranchers, farmers, and feedlot operators. Ranchers constitute a group that makes extensive use of land relative to the number of cattle. Farmers raise beef more intensively, often in connection with other enterprises. Farmers and ranchers may use supplements of hay, grain, or commercial feeds.

Feedlot operators are specialized cattle feeders who engage in very intensive production to bring animals to market weights. Emphasis is placed on the feeding of grain and commercial feeds. Calves and other feeder animals are usually purchased from farmers and ranchers.

Reference to Table III shows that a high proportion of slaughter cattle are sold directly to packing plants. In 1967 direct purchases amounted to 63.7 percent as compared to 34.0 percent through terminal markets and 2.3 percent through auction markets.

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[1] *Ibid.*, p. 225.

Terminal Markets

In 1967 three terminal markets, located at Calgary, Edmonton, and Lethbridge handled approximately 37.3 percent of the cattle marketings in Alberta. Auction markets handled 29.8 percent, while direct purchases accounted for 32.9 percent. Table 3 shows that there has been a decline in the proportion of sales on terminals relative to auction markets and direct purchases. Sales on terminals fell from 63.9 percent in 1958 to 37.3 percent in 1967. In the same period auction market sales rose from 12.6 percent to 29.8 percent, while direct purchases rose from 23.5 percent to 32.9 percent.

The terminals are owned by stockyard companies, which provide the physical facilities for assembling, weighing, feeding, and watering. In addition, they provide auction rings, auctioneers, and clearing facilities for exchange transactions. Farmers, feedlot operators, commission agents, order buyers, packer buyers, and other agents compete in the auction rings.

Auction Markets

There were fifty-eight Class D or regular auction markets in Alberta in 1967. These are situated at various population centres throughout the Province at distances of about fifteen to thirty miles from each other.[1]

Within the last decade the number of livestock auctions and the

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[1] T. W. Manning, Country Livestock Auctions and Market Performance, Technical Bulletin 1 (Edmonton: Department of Agricultural Economics, The University of Alberta, September, 1966).

Table 3

MARKETINGS OF CATTLE* AND CALVES ON AUCTION AND TERMINAL MARKETS, AND DIRECT PURCHASES BY PACKERS IN ALBERTA (1958-1967)

Year	Auction Markets				Terminal Markets				Direct to	Grand
	Feeder	Slaughter	Calves	Total	Feeder	Slaughter	Calves	Total	Packers	Total
				(number of head)						
1958	81,029	10,502	39,977	131,508	167,020	360,495	136,685	664,200	244,583	1,040,291
1959	92,906	15,889	53,477	164,477	156,983	315,489	108,556	581,028	343,188	988,693
1960	164,119	20,609	80,884	276,612	139,597	359,995	90,862	590,454	293,203	1,160,269
1961	180,982	57,698	111,340	350,020	151,503	333,204	122,390	607,097	377,089	1,334,206
1962	217,519	44,613	134,668	396,800	178,866	324,886	147,450	651,202	374,436	1,422,508
1963	232,845	53,569	160,227	446,641	185,807	290,347	123,729	599,883	418,542	1,442,976
1964	273,717	47,559	150,732	472,008	197,704	318,047	125,383	641,134	499,429	1,612,571
1965	307,028	30,438	182,668	520,134	262,751	365,025	176,920	804,696	559,567	1,884,397
1966	372,502	26,874	171,896	571,272	245,372	398,903	163,700	807,975	602,371	1,981,618
1967	413,485	23,544	151,139	588,168	221,183	348,074	166,882	736,139	651,153	1,975,460

*Exclusive of Dairy Cows.

Source: Data published in Canada Department of Agriculture, Annual Livestock Market Review; and statistics from the Livestock Division, Alberta Department of Agriculture.

number of cattle handled by them have more than doubled. They have thus become a very important agency in cattle marketing in Alberta. They seem to have a comparative advantage over terminals in the handling of feeder cattle because of their proximity to the main cattle-producing centres and the location of buyers and sellers in the same community.[1] In 1967 auction markets handled 65.0 percent of the feeder cattle in Alberta, while the remainder went through the terminals.

Auction markets are owned and operated principally by local partnerships and private individuals. They provide services similar to those of the terminal markets. In addition, auction operators may act as dealers, order buyers, or perform many of the functions of commission firms.

Packing Plants

Most of the slaughter cattle in Alberta go to eleven packing plants operated by seven companies. In addition, there are several smaller packing plants and a large number of federally uninspected establishments.

A large number of agents called packer buyers are associated with the packers. They buy cattle from the terminals, auction markets, or at buying stations owned and operated by the packing plants.

Other Agencies

Several commission firms operate offices at the terminals and in some cases at the larger auction markets. They act as commission agents for producers and packing plants. The commission firms charge

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[1] *Ibid.*, p. 17

a fee for their services, plus whatever costs they incur in tending the animals. The Alberta Livestock Cooperative also has offices at the public stockyards and provides similar services, but it acts on behalf of its patrons in keeping with cooperative ideals.

Private shippers and shipping associations of producers operating on a cooperative basis constitute another agency for the marketing of cattle. The private shippers may act on behalf of the producers, the packing plant, or both. The function is one of assembling and transporting cattle to the packing plants. They receive a fee for defraying transportation costs from the producers or packers plus a commission, and sometimes "bonuses."[1] Similar services are provided by the shipping associations, most of which are affiliated with the Alberta Livestock Cooperative. They may, however, make direct negotiations with the producers and packing plants.

Dealers, truckers and order buyers are generally private individuals who perform some of the marketing functions. Dealers operate as speculators assuming the risks associated with the entrepreneurial functions. Truckers provide mainly transportation services. Order buyers are agents of producers or packers providing services similar to those of the commission firms.

Channels

Figure 2 shows the various channels of distribution and the

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[1] T. W. Manning, The Performance of The Hog Marketing System in Alberta, Research Bulletin 4 (Edmonton: Department of Agricultural Economics, The University of Alberta, May, 1967). p. 17.

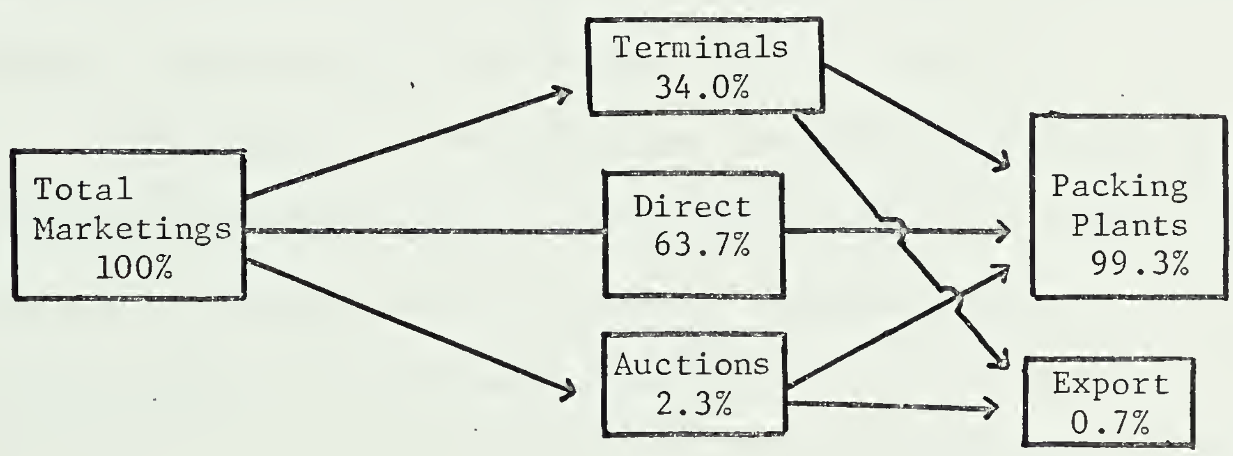
proportion of slaughter cattle going to packing plants via these channels in 1967. Feeder cattle are sold on auctions and terminals and are returned to producers.

Pricing of Cattle

Prices for cattle are arrived at by bidding on the terminal or auction markets or by direct haggling of buyers and sellers. In the large cities the information media make allowances for the dissemination of terminal market prices; small town newspapers carry the local auction market prices. Some economists express the view that the prices generated at the terminals serve as a guide for the pricing of cattle at other markets in the Province. Since there has been a relative decline in the number of cattle sold through the terminal markets,

Figure 2

MARKETING CHANNELS FOR SLAUGHTER CATTLE AND CALVES IN ALBERTA, 1967



Source: Data published in Canada Department of Agriculture, Annual Livestock Market Review; and annual reports of the Livestock Division, Alberta Department of Agriculture.

of true market conditions.[1]

Review of the Literature on the Analysis of Live Cattle Prices

Little, if anything, has been published on the analysis of live cattle prices in Alberta. Even for Canada and the United States only limited study has been done in this area. Two studies conducted under the aegis of the North Central Regional Livestock Marketing Research Committee in the United States are of particular interest to this review.

Schaars and Bray[2] in 1950 reported a study designed to determine the desirability and practicability of marketing veal calves on a carcass grade and carcass weight basis. The practice at that time was to buy and price calves on the hoof and to sell the carcasses almost entirely on the basis of packers' grades. The problem was to determine whether the current buying and pricing method provided equitable treatment for both buyers and sellers. In other words, to what extent did carcass values compare with prices paid for calves.

The answer to the problem was obtained by analyzing the relative accuracy with which buyers could determine yield and grade under the present liveweight method of purchase. Observations were made on 613 calves delivered at two packing plants.

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[1]National Commission on Food Marketing, Food from Farmer to Consumer (United States Government Printing Office, Washington, D.C.: June, 1966), pp. 22-23.

[2]M. A. Schaars and R. W. Bray, Pricing Veal Calves, Research Bulletin 170 (Madison: University of Wisconsin, November, 1950).

It was found that 45 percent of the calves were priced higher than the respective adjusted carcass values and 55 percent were priced lower. On the average the buyers' purchase prices were in line with the adjusted carcass valued. This finding did not imply, however, that the individual farmer with one or two calves to sell also received prices comparable to the carcass values of the calves he sold. The data also showed that there was a definite tendency to price the heavier calves of a given grade higher than the lighter calves of the same carcass grade.

In 1954 Clifton reported a similar study to measure the pricing efficiency of the current marketing system for slaughter cattle, veal calves, and lambs.[1] The results of the study again indicated that the producers of the better grades and higher yielding livestock were sometimes penalized, whereas the producers of the lower grades and lower dressing animals were often paid more than their animals were worth. The results indicated a need for improving the pricing efficiency.

On the Canadian scene, J. W. Clarke, commenting on the prices of farm products, stated that there was a cyclical pattern generated due to the relationship between price and production.[2] This pattern held for all types of livestock, including cattle. It was also suggested that export conditions were influential in determining livestock prices in

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[1] E. S. Clifton, Pricing Accuracy of Slaughter Cattle, Veal Calves, and Lambs, Station Bulletin 611 (Indiana: Purdue University Agricultural Experiment Station, October, 1964).

[2] J. W. Clarke, "Prices of Farm Products in Canada," Unpublished Paper Presented at Farm Conference Week, University of Manitoba, March, 1967.

Canada. The results of the analysis presented in the following chapter showed that certain categorical variables were important in explaining price variation in Alberta.

CHAPTER IV

RESULTS OF THE ANALYSIS

The Problem Restated

The main hypothesis might be restated in algebraic form thus:

$$P = a + T_i + C_j + W_k + B_l + Cd_m + G_n + H_o + M_p + A_q + e \qquad (4.1)$$

in which:

P = price, a quantitative, dependent variable		
a = intercept term		
T_i = type	$i = 1, 2.$	
C_j = class	$j = 1, 2, \ldots, 5.$	
W_k = weight	$k = 1, 2, \ldots, 5.$	
B_l = buyer	$l = 1, 2, \ldots, 5.$	
Cd_m = condition	$m = 1, 2, 3.$	
G_n = grade	$n = 1, 2, \ldots, 6.$	
H_o = horns	$o = 1, 2.$	
M_p = market	$p = 1, 2.$	
A_q = geographic area	$q = 1, 2, 3.$	
e = error term		

The subsidiary hypotheses were of the form:

$$P = f(T_i, C_j, \ldots, A_q), \qquad (4.2)$$

where

$T_i, C_j, \ldots, A_q$, denote the variables specified in (4.1) and took the values 1 or 0, depending on whether that variable was included or not.

Table 4

ASSIGNMENT OF DUMMY VARIABLES AND INTERPRETATION

Group Variable	Specific Variable	Symbol	Values	Interpretation
		P - Price, a quantitative dependent variable		
Type	Feeder	T_1	1	If feeder
	Slaughter	T_2	-1	If slaughter
Class	Bull	C_1	1 0	If bull If not bull
	Cow	C_2	1 0	If cow If not cow
	Steer	C_3	1 0	If steer If not steer
	Heifer	C_4	1 0	If heifer If not heifer
	Calf	C_5	-	If Calf then $C_1, C_2, \ldots, C_4 = -1$
Weight	<300	W_1	1 0	In this category Not in this category
	300 - 499	W_2	1 0	In this category Not in this category
	500 - 699	W_3	1 0	In this category Not in this category
	700 - 999	W_4	1 0	In this category Not in this category
	1000+	W_5	-	If 1000+ then $W_1, W_2, \ldots, W_4 = -1$
Buyer	Farmer	B_1	1 0	If farmer If not
	Feedlot Operator	B_2	1 0	If feedlot operator If not
	Dealer	B_3	1 0	If dealer If not
	Order Buyer	B_4	1 0	If order buyer If not
	Packer Buyer	B_5	-	If packer buyer then $B_1, B_2, \ldots, B_4 = -1$

Table 4 (continued)

Group Variable	Specific Variable	Symbol	Values	Interpretation
Condition	Full	Cd_1	1	If full
			0	If not full
	Medium	Cd_2	1	If medium
			0	If not medium
	Empty	Cd_3	-	If empty then Cd_1 and $Cd_2 = -1$
Grade	Choice	G_1	1	If choice
			0	If not choice
	Good	G_2	1	If good
			0	If not good
	Medium	G_3	1	If medium
			0	If not medium
	Plain	G_4	1	If plain
			0	If not plain
	Overfat	G_5	1	If overfat
			0	If not overfat
	Boner	G_6	-	If boner then $G_1, G_2, \ldots, G_5 = -1$
Horns	Present	H_1	1	If present
	Absent	H_2	-1	If absent
Market	Terminal	T_1	1	If terminal market
	Auction	T_2	-1	If auction market
Area	North	A_1	1	If north
			0	If not north
	Central	A_2	1	If central
			0	If not central
	South	A_3	-	If south then A_1 and $A_2 = -1$

The Estimation Procedure

Dummy variables were assigned to the independent variables as shown in Table 4. Regression equations were generated to test the subsidiary hypotheses for each of the types of livestock -- feeder and slaughter. Subsequently a regression equation involving all the variables was generated to test the main hypothesis. It was assumed that interaction effects were nonexistent.[1]

Summary of the Results

The following discussion is based on the equations generated to test the hypotheses. The regression coefficients and other statistical properties of these equations are presented in Table 5 and 6. With the exception of Table 5 all the symbols used in this discussion have the same interpretation as given in Table 4. In all cases P refers to price and is measured in cents per hundred pounds liveweight.

Tests of significance of the regression equations were based on the F statistic. The tests of significance of the individual coefficients were based on the t values. However, much emphasis was not placed on the tests of the individual coefficients.[2] In making comparisons between

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[1]J. N. Morgan and J. A. Sonquist, op. cit., p. 423, pointed out that this assumption did not severely limit the efficiency of the analytic procedure and greatly reduced the computational problems.

[2]E. Melichar, op. cit., p. 19, suggested that an individual coefficient should not be regarded as unimportant merely because it did not differ significantly from zero. Since intra-group comparisons were the main concern, tests of individual coefficients were not of particular importance.

intra-group coefficients, the t test was employed by comparing the difference between the coefficients and the standard error of this difference. The standard error of the difference was computed as the square root of the sum of squares of the standard errors of the coefficients that were compared.[1] In all cases a positive test at the 0.05 level was regarded as significant, while that at lower levels was not significant. Thus a hypothesis was rejected when the F statistic of the regression equation did not yield a positive test at the 0.05 level of significance.

Price versus Class

It was hypothesized that price was a function class. The regression equations generated for feeder and slaughter cattle were:

Feeder : $P = 1770.6 + 25.6C_1 - 460.7C_2 + 184.5C_3 - 50.0C_4 + 300.6C_5 + e$ (4.1a)

Slaughter: $P= 1790.8 - 209.7C_1 - 455.9C_2 + 327.7C_3 + 25.9C_4 + 312.0C_5 + e$ (4.1b)

In both cases the null hypothesis was rejected.

The coefficients of the equations measure the amount of the deviation attributable to each class of cattle. Deviations from the intercept for feeder cows and heifers were negative, while those for feeder bulls, steers, and calves were positive. Feeder calves were priced higher than feeder steers by $1.16, as indicated by the deviation of $3.01 for calves and $1.85 for steers. The deviation from the

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[1] Ibid.

intercept for bulls was 26 cents, and that for heifers was 50 cents. Thus feeder steers were sold on the average \$1.59 higher than feeder bulls and \$2.34 higher than feeder heifers. There was a negative deviation from the intercept of \$4.61 for feeder cows; that is, they were priced \$7.62 lower than feeder calves and \$5.10 lower than heifers. With the exception of the coefficient for feeder bulls all coefficients were significantly different from zero. They also differed significantly from each other. All coefficients expressed average relationships.

The pattern of the relationship for slaughter cattle was somewhat different. Slaughter bulls were priced lower than the average by \$2.10, while cows were even lower with a negative deviation of \$4.56. Slaughter steers were priced 16 cents higher than veal calves and \$3.02 higher than heifers. Here all coefficients were significantly different from zero, and with the exception of those for steers and calves, they were significantly different from each other.

<u>Price versus Weight</u>

The test of the hypothesis that price was a function of weight yielded the following equations. The null hypothesis was rejected.

$$\text{Feeder}: \quad P = 1872.5 + 284.9W_1 + 44.3W_2 - 36.1W_3 - 67.1W_4 - 236.0W_5 + e \qquad (4.2a)$$

$$\text{Slaughter}: \quad P = 1834.4 + 361.3W_1 + 94.0W_2 - 96.4W_3 - 66.0W_4 - 302.9W_5 + e \qquad (4.2b)$$

For feeder cattle deviations from the intercept ranged from \$2.85 for animals less than 300 pounds to minus \$2.36 for animals 1,000 pounds and over. The amount of the deviation became smaller and smaller for each successive weight range. This relationship suggests that

there was a steady decline in price as weight increased. Though all coefficients were significantly different from zero, those for W_3 and W_4 did not differ significantly from each other.

This relationship did not hold true for slaughter cattle. There was a decline in prices as weight increased up to 500 - 699 pounds, followed by an increase for animals between 700 - 999 pounds, and then a sharp decline for animals 1,000 pounds and over. Again all coefficients were significantly different from zero, while those for W_3 and W_4 were not significantly different from each other.

Price versus Buyer

It was hypothesized that price was a function of buyer. The regression equations for the two types of cattle were:

$$\text{Feeder}: \quad P = 1826.8 + 28.6B_1 + 29.3B_2 - 16.9B_3 + 70.3B_4 - 101.3B_5 + e \qquad (4.3a)$$

$$\text{Slaughter}: \quad P = 1672.4 - 71.8B_1 + 69.5B_2 - 118.0B_3 + 102.5B_4 + 17.8B_5 + e \qquad (4.3b)$$

In neither case was the hypothesis rejected.

For feeder cattle the coefficients for farmers, feedlot operators, and dealers were not significantly different from zero. However, while the coefficients for farmers and feedlot operators were not different from each other, they were both significantly different from that for dealers. Dealers were the highest bidders on feeder cattle, while packer buyers were at the bottom. The coefficient for packer buyers differed significantly from all others.

In the case of slaughter cattle order buyers were again the highest bidders, while dealers were the lowest. Coefficients for these

two groups of buyers were the only ones significantly different from zero and from each other.

These results indicate that order buyers, feedlot operators, and farmers tended to bid high on feeder cattle, while dealers and packer buyers were low bidders. Order buyers and dealers were the high and low bidders, respectively, on slaughter cattle, while feedlot operators, packer buyers, and farmers were in between.

Price versus Condition

The hypothesis was that price was a function of condition.[1] The following equations were generated. In both cases the null hypothesis was rejected.

$$\text{Feeder}\quad : \quad P = 1832.8 - 37.7Cd_1 + 0.8Cd_2 + 37.0Cd_3 + e \qquad (4.4a)$$

$$\text{Slaughter}: \quad P = 1662.2 - 77.3Cd_1 + 67.3Cd_2 + 10.0Cd_3 + e \qquad (4.4b)$$

For both types buyers discounted for full cattle and paid a premium for medium and empty cattle. Full feeders were discounted 38 cents. This amount was significantly different from zero. Medium feeder cattle were about average with a positive, but insignificant, deviation of only one cent. Empty feeders, however, received a premium of 37 cents. The coefficient was also significantly different from zero. All coefficients differed from each other significantly.

The deviation from the intercept for full slaughter cattle was

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[1]The three categories of this variable, namely, full, medium, and empty refer to the physical appearance of the animal resulting from the ingestion of food and water as judged at the time of sale. Thus an animal with a distended stomach would be regarded as full and one with a flat stomach would be empty. An animal that had neither a distended nor a flat stomach was of medium condition.

minus 75 cents. The deviation for medium slaughter cattle was plus 67 cents. There was a positive deviation of 10 cents for empty slaughter cattle. Here the coefficient for empty slaughter cattle was not significantly different from zero, but all the coefficients were significantly different from each other.

Price versus Grade

It was hypothesized that price was a function of grade. The regression equations generated were:

$$\text{Feeder}: \quad P = 1786.5 + 171.0G_1 + 10.1G_2 - 181.1G_3 + e \qquad (4.5a)$$

$$\text{Slaughter}: \quad P = 1586.5 + 479.1G_1 + 103.6G_2 + 94.6G_3 - 174.5G_4 - 229.6G_5 - 291.2G_6 + e \qquad (4.5b)$$

There was a positive deviation of \$1.71 for choice feeders. The deviation for medium feeder cattle was 10 cents, which was not significantly different from zero. That for plain feeders was minus \$1.81. Thus choice feeders sold \$1.60 more than medium feeders and \$3.52 more than plain feeders. The coefficients differed significantly from each other, and those for choice and plain feeders were significantly different from zero. The price differentials among grades were uniform as indicated by the actual amount of the deviations from the intercept.

The price differentials among the various grades of slaughter cattle were not as uniform as those for feeders. Choice slaughter cattle received a premium as indicated by the positive deviation of \$4.97. Good cattle sold \$3.94 lower than choice cattle, but only nine cents higher than medium cattle. There were negative deviations for slaughter animals of lower than medium grade. Plain slaughter cattle

were priced \$6.54 lower than choice cattle and \$2.69 lower than medium cattle. The differential between plain cattle and overfat cattle was 50 cents and between overfat cattle and boners was a difference of 62 cents. Therefore, choice slaughter cattle were priced \$7.70 higher than boners. All coefficients were significantly different from zero. The differentials between plain and overfat cattle and between overfat cattle and boners was not significant.

Price versus Horns and Market

The test of the hypothesis that price was a function of horns and market yielded the following equations:

Feeder : $P = 1854.9 - 45.0H_1 + 45.0H_2 - 0.2M_1 + 0.2M_2 + e$ (4.6a)

Slaughter: $P = 1689.5 - 54.5H_1 + 54.5H_2 - 115.5M_1 - 115.5M_2 + e$ (4.6b)

The hypothesis was not rejected.

The deviation from the intercept for feeders without horns was 45 cents, while for feeders with horns the deviation was minus 45 cents. Therefore, feeders without horns were priced 90 cents higher than those with horns. The deviation attributable to type of market was negligible.

Slaughter cattle without horns sold \$1.09 higher than those with horns. Slaughter prices were on the average \$2.31 higher at terminals than at auctions. This amount was the difference of the deviations from the intercept attributable to each type of market

Price versus Area and Market

It was hypothesized that price was a function of area and

market.[1] The regression equations were as follows:

$$\text{Feeder}: \quad P = 1839.0 + 4.3A_1 - 26.8A_2 + 22.4A_3 - 4.3M_1 + 4.3M_2 + e \qquad (4.7a)$$

$$\text{Slaughter}: \quad P = 1673.5 - 10.1A_1 - 29.6A_2 + 39.6A_3 + 114.5M_1 - 114.5M_2 + e \qquad (4.7b)$$

The hypothesis was rejected in the case of feeder cattle but was not rejected for slaughter cattle.

Despite the fact that the hypothesis was rejected in the former case, the following relationships were shown. The deviations from the intercept term were four cents for the North, minus 27 cents for the Central region, and plus 22 cents for the South. Only the coefficient for the Central region and the difference between it and that for the South were significantly different from zero. In this instance feeder cattle were priced nine cents higher at auctions than at terminals but again this difference was not significant.

For slaughter cattle there was a ten cent decrease in the intercept term for animals sold in the North. Animals sold in the Central region were priced lower than the average by 30 cents, while animals in the South were 40 cents above average. Again average slaughter cattle price was $2.30 higher at terminals than at auctions, a difference that was significant.

Three General Equations

Price was regressed on all the independent variables except

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[1] This variable was included for comparison with 4.6a and 4.6b.

type. Finally, price was regressed on all the independent variables, thus pooling the whole sample. This last regression was performed to test the main hypothesis. The regressions for the two types of cattle might be considered tests for two additional subsidiary hypotheses. The least squares estimates and other statistical properties of these equations are given in Table 6.

In general, the statistical relationships brought out by the three general equations were similar to those of the already discussed subsidiary equations. A few exceptions are worth noting here.[1]

The coefficient for empty slaughter cattle became significantly different from zero but was not different from the coefficient of medium slaughter cattle. The difference between the coefficients for horns was insignificant for both types of cattle.

Whereas the differential between auction and terminal markets was insignificant for feeders in the subsidiary equations, it was significant in the general equation for the feeder sample. None of the coefficients for area were significantly different from zero or from each other as indicated by the general equation for feeder cattle. In the case of slaughter cattle the average price in the North and South was significantly higher than that in the Central Region, but these average prices were not significantly different from each other.

For the entire sample there was no difference due to type of

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[1]The differences in the coefficients may be due to the effect of bringing together all the independent variables in the regression equation. Dr. K. W. Smillie of the Department of Computing Science, The University of Alberta, agreed that it was not uncommon to find such changes occurring in regression analysis.

Table 5

LEAST SQUARES ESTIMATES, MULTIPLE CORRELATION, AND STANDARD ERRORS OF REGRESSION EQUATIONS GENERATED BY TESTING SUBSIDIARY HYPOTHESES

Group Variable	Equation Number	Intercept	Regression coefficients (Standard Error) b_1	b_2	b_3	b_4	b_5	b_6	R^2	Standard Error
			Price -- the dependent variable, in cents per 100 lbs.							
Class	(4.1a)	1770.6	25.6[a]	-460.7	184.5	-50.0	300.6		63.6	225.8
			(19.6)	(15.5)	(8.8)	(10.2)	(28.4)			
	(4.1b)	1790.8	-209.7	-455.9	327.7	25.9	312.0		87.1	187.0
			(15.2)	(7.5)	(8.7)	(8.7)	(20.9)			
Weight	(4.2a)	1872.5	284.9	44.3	- 36.1	-67.1	-236.0		24.6	283.8
			(29.2)	(15.7)	(13.5)	(13.9)	(38.4)			
	(4.2b)	1834.4	361.3	94.0	- 96.4	-66.0	-302.9		37.6	353.3
Buyer	(4.3a)	1826.8	28.6[a]	29.3[a]	- 16.9[a]	70.3	-101.3		13.0	290.2
			(16.3)	(15.3)	(13.3)	(14.5)	(29.8)			
	(4.3b)	1672.4	-71.8[a]	69.5[a]	-118.0	102.5	17.8[a]		14.0	377.5
			(92.5)	(62.9)	(33.0)	(36.5)	(122.2)			
Condition	(4.4a)	1832.8	-37.7	0.8[a]	37.0				8.8	291.4
			(12.1)	(9.0)	(15.1)					
	(4.4b)	1662.2	-77.3	67.3	10.0[a]				12.3	378.2
			(15.3)	(12.3)	(19.6)					

Table 5 (continued)

Group Variable	Equation Number	Intercept	Regression coefficients (Standard Error) b_1	b_2	b_3	b_4	b_5	b_6	R_2	Standard Error
Grade	(4.5a)	1786.5	171.0 (7.7)	10.1[a] (8.1)	-181,1 (11.2)				42.8	264.4
	(4.5b)	1586.5	479.1 (16.1)	103.6 (13.6)	94.6 (15.6)	-174.5 (18.6)	-229.6 (44.2)	-291.2 (54.7)	62.7	279.6
Horns, Market	(4.6a)	1854.9	-45.0 (15.3)	45.0 (15.3	-0.2[a] (6.4)	-0.2[a] (6.4)			6.1	292.0
	(4.6b)	1689.5	-54.5 (23.0)	54.5 (23.0)	115.5 (7.8)	-115.5 (7.8)			30.8	362.6
Area, Market	(4.7a)	1839.0	4.3[a] (8.8)	-26.8 (12.0	22.4[a] (14.9)	-4.3[a] (6.7)	4.3[a] (6.7)		5.3	292.3
	(4.7b)	1673.5	-10.1[a] (12.3)	-29.6[a] (17.3)	39.6[a] (21.2)	114.5 (8.4)	-114.5 (8.4)		31.2	362.1

Note: The symbols b_1, b_2....,b_6 correspond to the coefficients of the specific variables in Table 4 in the order 1 to k, where k is the last category of that group. When groups are in combination, b_{k+1} denotes the coefficient of the first specific variable of the second group, and $b_{k+}k$, is the coefficient of the last specific variable of the second group and so on. The standard errors are given in brackets beneath the coefficients.

[a]Coefficient not significantly different from zero.

[A]F statistic of the regression equation not significant at the 0.05 level.

Table 6

LEAST SQUARES ESTIMATES, MULTIPLE CORRELATION, AND STANDARD ERRORS OF THE THREE GENERAL EQUATIONS

Group Variable	Specific Variable	Symbol	Regression Coefficients (Standard Error) Feeder (A)	Slaughter (B)	Whole Sample (C)
			P - Price, the dependent variable		
	Intercept Term		1703.7	1729.4	1704.3
Type	Feeder	T_1	-	-	99.2(5.0)
	Slaughter	T_2	-	-	-99.2(5.0)
Class	Bull	C_1	63.0(15.6)	70.9(14.1)	74.0(10.6)
	Cow	C_2	-416.6(13.3)	-438.0(7.4)	-425.1(6.6)
	Steer	C_3	222.6(7.7)	216.3(7.9)	225.9(5.5)
	Heifer	C_4	-53.2(8.7)	-42.8(8.1)	-39.7(6.0)
	Calf	C_5	184.3(23.6)	194.6(19.5)	164.9(14.9)
Weight (in lbs.)	300	W_1	145.8(24.2)	128.4(21.4)	151.9(16.4)
	300 - 499	W_2	28.9(10.1)	-48.3(14.3)	12.2[a](7.0)
	500 - 699	W_3	-54.2(9.7)	-55.0(12.2)	-59.3(6.0)
	700 - 999	W_4	-61.4(10.1)	-13.3[a](10.1)	-55.9(6.2)
	1000+	W_5	-59.1(30.1)	-21.8[a](30.2)	-48.9(20.0)
Buyer	Farmer	B_1	27.7(10.7)	30.5[a](31.1)	29.1(7.8)
	Feedlot Operator	B_2	-30.0(9.8)	-23.3[a](21.3)	-33.8(6.9)
	Dealer	B_3	-24.8(8.1)	-24.5(11.2)	-32.1(9.6)
	Order Buyer	B_4	44.6(9.4)	-1.4[a](12.4)	21.0(5.7)
	Packer Buyer	B_5	-17.7[a](19.1)	18.7[a](41.2)	15.7[a](15.3)

Table 6 (continued)

Group Variable	Variable	Symbol	Regression Coefficients (Standard Error) Feeder	Slaughter	Whole Sample
Condition	Full	Cd_1	-24.4(7.4)	-36.2(5.2)	-26.8(4.6)
	Medium	Cd_2	2.0[a](5.5)	17.4(4.2)	10.9(3.6)
	Empty	Cd_3	22.4(9.2)	18.8(6.7)	15.9(5.8)
Grade	Choice	G_1	184.4(5.4)	263.7(7.8)	274.4(7.2)
	Good	G_2	-	138.5(6.1)	95.0(7.5)
	Medium	G_3	36.8(5.5)	48.2(7.0)	144.7(8.5)
	Plain	G_4	-221.2(8.3)	-82.7(8.2)	-64.0(6.8)
	Overfat	G_5	-	-107.8(19.2)	-149.0(23.8)
	Bone	G_6	-	-259.9(24.1)	-301.1(28.1)
Horns	Present	H_1	-3.1[a](4.7)	-7.9[a](4.1)	-5.7[a](3.3)
	Absent'	H_2	3.1[a](4.7)	7.9[a](4.1)	5.7[a](3.3)
Market	Terminal	M_1	-8.5(4.8)	11.8(3.3)	1.0[a](2.9)
	Auction	M_2	8.5(4.8)	-11.8(3.3)	-1.0[a](2.9)
Area	North	A_1	10.3[a](5.5)	11.9(4.4)	8.1(3.6)
	Central	A_2	-1.3[a](7.7)	-18.1(6.2)	-7.7[a](5.1)
	South	A_3	-9.0[a](9.9)	6.3[a](7.6)	0.4[a](6.2)
Multiple Correlation			80.5%	94.4%	89.3%
Standard Error of Estimate			174.2	126.1	157.3

Note: The standard errors of the regression coefficients are in parentheses. Coefficients with an a superscript were not significantly different from zero.

market. The effects of high feeder prices at auctions and high slaughter prices at terminals seemed to nullify each other. The effect of horns was not significant, but the indication still remained that the presence of horns tended to depress price. Prices were higher in the North than in the Central Region. The coefficients for Central and South were not significantly different from zero or from each other. In the following section the analytic results are discussed in relation to the objectives of the study.

Results in Relation to Objectives

Quantification of Factors

The incorporation of dummy variables in the regression equations afforded a means of quantifying the categorical variables. Even in the case of weight, which was measured on a numerical scale, dummy variables were used in categorizing the observations. The results of this analysis suggest that the technique was effective in bringing out meaningful relationships between price and the categorical or qualitative independent variables.

Variation Explained

In general, there was a highly significant relationship between price and the independent variables. A comparison of column (A) and (B) in Table 6 showed that there was a higher multiple correlation for slaughter cattle than for feeder cattle, 94 percent as compared with 80 percent. The multiple correlation for the whole sample was 89 percent. The F values for all the regression equations were significant to the 0.01 level.

Differentiation of the Markets

In the marketing of feeder and slaughter cattle the same marketing facilities are used. The markets for these two types of cattle, however, possess certain characteristics that support the view that the markets for feeder and slaughter cattle are differentiated. T. W. Manning found that the auction markets in Alberta had a special advantage in handling feeder livestock because buyers and sellers often were located in the same community.[1] The regression coefficients for terminal and auction markets in column (a) of Table 6 support this conclusion in that feeder prices were higher at auctions than at terminals. Equations (4.6b) and (4.7b) of Table 5 showed that prices of slaughter cattle were significantly higher at terminals than at auctions. The same result was obtained in Table 6. These relationships could not have been determined by a general model for feeder and slaughter cattle (see column (C), Table 6).

The multiple correlation due to the same factors was greater for slaughter cattle by 14 percent, suggesting that other variables must be sought to explain more of the variation in prices of feeder cattle. One such factor might be the expected prices for slaughter cattle.

It was found that when the coefficients of the whole sample regression were used to arrive at average prices, there were significant differences between these prices and those arrived at when the

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[1]T. W. Manning, Country Livestock Auctions and Market Performance, Technical Bulletin 1 (Edmonton: Department of Agricultural Economics, The University of Alberta, September, 1966), p. 17.

coefficients of the type sample were used. For example, the price of a choice feeder steer, empty and without horns, weighing 500 to 700 pounds, and bought by a farmer at an auction market in the North was $21.20 when the coefficients for column (A) were used and $22.88 when those from column (C) were used.

These differences raised the question of the degree of validity of a general model for explaining price variation for both types of cattle. Separate models would have greater validity on the grounds that specification of such models would be more exact and that the relevant variables that bring out the characteristic relationships of the two types could be more effectively employed.

The peculiarities of the markets for the two types of cattle serve to differentiate them. Similarities between the markets are recognized but conceptually they are distinct entities. This idea of differentiated markets are supported by the results of the analysis, indicating the necessity of having separate models for explaining variation in cattle prices.

Price Comparison between Market Types

As already stated, the study indicated that slaughter cattle were priced higher at terminals than at auctions, while feeders were priced higher at auctions than at terminals. For the whole sample, however, there was no significant difference between prices at auction and terminal markets.

Price Comparison between Areas

The differences between the results in equations 4.7a and 4.7b in Table 5 and those in Table 6 have already been discussed. In general, the results showed that whatever differences there were between the different areas were unimportant.

CHAPTER V

IMPLICATIONS OF THE RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Implications

The analytic results point out certain implications with regard to cattle production and marketing in Alberta. These implications, based on empirical research, could provide a basis for policy formulation and recommendation. These are discussed with respect to the independent variables used in the study. Emphasis is placed on the results presented in Table 5.

Type

The results indicated that the markets for feeder and slaughter cattle are differentiated. Attempts to analyze the effects of certain factors on observed characteristics of these two types without first categorizing them could yield misleading results. The implication here is that research into relationships involving the two types of cattle requires two separate models. In some cases, or with more sophisticated analytic tools, a single model might be appropriate.

Class

Class was a very important variable in explaining variation in cattle prices, especially in the case of slaughter cattle. Feeder steers were priced \$2.34 higher than feeder heifers and slaughter steers sold \$3.02 higher than slaughter heifers. One implication is that the price difference between feeder steers and feeder heifers is more than compensated for when the animals are sold as slaughter cattle.

Producers who are not aware of this relationship stand to lose if they place too much emphasis on feeder heifers. Feedlot operators are likely to make this mistake since feeder heifers may be bought at a lower price.

Another important implication arises from the fact that feeder steers are priced $1.59 higher than feeder bulls, while slaughter steers sold $5.39 higher than slaughter bulls. Here again the higher price received for slaughter steers was greater by more than the difference between the average prices of the feeder animals. This relationship is important since bulls could be converted into steers. Producers of feeder and slaughter bulls stand to gain if they convert bulls into steers by castration. The timing of this operation is important, since older animals are less manageable and more susceptible to diseases.

The relationships reflect a higher demand for meat from steers. Producers should take advantage of this demand. Sex determination, however, is genetically controlled, and thus raises considerations beyond this study.

Weight

As liveweight increased, there was a decline in price. The implication here is that the optimum weight at which to sell the various classes of livestock should be investigated. This consideration is an important one since the feed conversion potential of animals decreases with age.

The results also indicated that the technique of dummy variables could be used effectively in determining the optimum weights.

The analysis could be done by reclassifying the variable into narrower ranges for the different categories (classes) of cattle.

Buyer

The forces of competition on the market are generated by the buyers bidding against each other in the auction ring. As the results indicated, there was a high degree of competition among the buyers of cattle. However, some comments must be made about the different buyers.

Order buyers were the highest bidders on both slaughter and feeder cattle. Their high bidding is understandable, since they act on behalf of patrons on a commission basis. The important implication, however, is that order buyers serve to make the markets more competitive. As the demand for cattle through order buyers increases, there should be a tendency for prices to rise. Since, however, patrons of order buyers pay higher prices, an increase in demand through order buyers may not be forthcoming.

Dealers were generally lower in their bidding. This low bidding is probably because these entrepreneurs are looking for bargains. Their effect on the market is opposite to that of order buyers. The fact that farmers bid on slaughter cattle implies that a certain number of slaughter cattle are bought by farmers for additional feeding.

The relatively low level of bidding on slaughter cattle by packer buyers might be related to the fact that a high proportion of cattle are sold directly to the packing plant (see Table 3), and the packer buyers might be more informed of the market demand. If the prices generated at the terminal markets serve as a guide for the

pricing of cattle on other markets including direct purchases, then the packers stand to gain by their agents' low bidding on the public stockyards. An expansion of the study to take into account direct purchases would provide further information on this aspect of marketing.

Condition

The results of the study showed that the physical condition of the animal was an important variable in explaining price differences. For both types, full cattle were priced lower than medium and empty animals. Empty feeder cattle received the best prices, while both medium and empty slaughter cattle were priced about the same (see Table 6). The implication here is that producers and their agents should pay attention to fill. Heavy feeding just prior to sale to increase weight may not increase income, since buyers discount for fill.

Grade

There was no official grading system for feeder cattle in operation when the study was made. The three grades for feeder cattle were assigned by the researcher. For slaughter cattle, however, the researcher estimated the various grades according to the official grading system in operation. The price differentials between the different grades for feeder cattle imply that the grading system used in the study could be effective if officially instituted.

The subsidiary hypothesis, price versus grade, showed that the differences in price for the various grades of slaughter cattle were erratic (see equation 4.5b, Table 5). The relationship seemed to suggest the Federal grades did not reflect the commercial value of the

animals. The results of the general equation for slaughter cattle indicated more uniform differentials (see Table 6), which suggests that the grading system might not be as poor as indicated by the subsidiary hypothesis.[1]

The general equation for the whole sample showed that medium grade cattle were priced 50 cents higher than good cattle. This apparent discrepancy arose from pooling the data, and lend further support to the view that the two types of cattle should have separate models.

Horns

Horned animals could be a menace on the farm, feedlot, or in transit to slaughter houses by inflicting injury to other animals. Dehorning, if done at an early age, is an inexpensive operation. In later stages the cost of dehorning could be high. Here the cost involves not only labour costs but also losses which might result from infectious diseases and decreased feed efficiency.

The study pointed out that animals with horns were on the average prices lower than those without horns. The difference was 90 cents in the case of feeders and $1.08 for slaughter cattle (see equations 4.6a and 4.6b of Table 5). In addition, a provincial charge of $2.00 per head is levied on the sale of horned animals. Producers would increase their income through higher market prices, decreased loss, and the absence of a charge if they dehorn animals at the right time.

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[1]Statements concerning the effectiveness of the grading system could only be conclusive if the researcher's judgment was in accordance with federal standards.

Market

The study showed that feeder cattle sold on the average higher at auctions than at terminals, while slaughter cattle were priced higher at terminals than at auctions. In the case of slaughter cattle the difference of $2.30 between terminal and auction markets was greater than could be accounted for if allowance was made for transportation cost.[1] This implies that producers might increase their earnings by taking their slaughter cattle to terminal markets.

The small deviations from the intercept for feeder cattle are understandable, since feeders sold on terminal markets most likely come from and return to producers located near terminals.

Area

The results from the general equations were different from those of the subsidiary equations. The differences between the areas were not sufficiently large to warrant diversion of supplies from one area to another. These differences were probably more related to local supply and demand conditions. However, when market and area considerations were taken together, they seemed to imply that the slaughter cattle might receive better prices if they went to terminals.

Conclusions and Recommendations

The technique of dummy variables in regression analysis has

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[1] See equations 4.6b and 4.7b. The transportation cost per hundred pounds liveweight from the Grande Prairie region to Edmonton is about $1.00.

provided a means of quantifying categorical or qualitative variables, hypothesized as affecting cattle prices. The technique was effective in bringing out the relationships between the dependent and the independent variables.

The results showed that the hypothesized variables were important in explaining variation in cattle prices. Class, grade, and weight were the most important variables judged by the amount of variation explained by these factors. The hypothesized variables explained 80 percent of the variation in feeder cattle prices, 94 percent of the variation in slaughter cattle prices, and 98 percent of the variation in prices for the whole sample.

The study concluded that:

(a) The markets for feeder and slaughter cattle were differentiated, thus necessitating the use of separate models for the two types. In general, feeder cattle were priced higher at auctions than at terminals and slaughter cattle sold higher at terminals than at auctions.

(b) If a grading system similar to that used in this study were adopted, it would be effective in reflecting the commercial values of the animals and in encouraging the production of better grades. The grading system for slaughter cattle did not reflect the commercial value of the animals.

(c) Full cattle received the lowest price, compared to medium and empty cattle. Producers stood to gain if they sold empty feeder cattle and medium or empty slaughter cattle rather than full cattle.

(d) The presence of horns tended to depress prices. An increase

in price could be expected if animals were dehorned.

(e) The conversion of bull calves into steers could result in higher prices to the farmer.

(f) There was no advantage in diverting supplies from one area to another. An increase in the number of slaughter cattle going to terminal markets might result in higher incomes to farmers.

(g) Price decreased with increase in liveweight.

The results of the study provide the basis for the following recommendations:

1. Dehorning and castration of male calves should be a regular farm practice.

2. Producers should pay attention to the condition of animals at the time of sale.

3. A review of the grading system for slaughter cattle is necessary, and a grading system for feeder cattle should be instituted.

4. Research into the optimum weights at which to sell feeder and slaughter is recommended.

APPENDIX

Table 7

CATTLE OBSERVATIONS BY HEAD, LOT AND TYPE
AT DIFFERENT MARKETS AND AREAS

Area, Market	Number of Lots			Number of Head		
	Slaughter	Feeder	Total	Slaughter	Feeder	Total
NORTH	253	344	597	314	466	780
Fairview	74	144	218	79	203	282
Dawson Creek	84	64	148	115	88	203
Grande Prairie	83	117	200	108	155	263
Rycroft	12	19	31	12	20	32
CENTRAL	993	1177	2170	1480	2021	3501
Edmonton[a]	625	518	1143	998	864	1862
Stettler	177	176	353	274	358	632
Ponoka	86	187	273	90	336	426
Red Deer	105	241	346	118	369	487
Lacombe	0	55	55	0	94	94
SOUTH	917	778	1695	1836	1798	3634
Calgary[a]	425	282	707	898	566	1464
Taber	9	44	53	14	230	244
Fort McLeod	266	102	368	574	194	768
Brooks	157	308	465	249	726	975
High River	60	42	102	101	82	183
TOTAL	2163	2299	4462	3630	4285	7915

[a]Terminal stockyards, all others are auctions.

Table 8

DISTRIBUTION OF LOTS BY TYPE AND CLASS

Type	Bull	Cow	Steer	Heifer	Calf	Total
Slaughter	106	944	506	506	101	2,163
Feeder	93	165	1286	619	136	2,299
Total	199	1109	1792	1125	237	4,462

Table 9

DISTRIBUTION OF LOTS BY TYPE AND WEIGHT
(POUNDS)

Type	300	300-499	500-699	700-999	1000+	Total
Slaughter	50	75	140	916	982	2,163
Feeder	67	424	974	787	47	2,299
Total	117	499	1114	1705	1029	4,462

Table 10

DISTRIBUTION OF LOTS BY TYPE AND BUYER

Type	Farmer	Feedlot Operator	Dealer	Order Buyer	Packer Buyer	Total
Slaughter	11	27	282	157	1686	2,163
Feeder	351	450	891	571	36	2,299
Total	362	477	1173	728	1722	4,462

Table 11

DISTRIBUTION OF LOTS BY TYPES AND CONDITION

Type	Full	Medium	Empty	Total
Slaughter	320	738	1105	2,163
Feeder	295	893	1111	2,299
Total	615	1631	2214	4,462

Table 12

DISTRIBUTION OF LOTS BY TYPE AND GRADE

Type	Choice	Good	Medium	Plain	Overfat	Boner	Total
Slaughter	401	784	449	248	32	249	2,163
Feeder	1119	-	833	347	-	-	2,299
Total	1520	784	1282	595	32	249	4,462

Table 13

DEVIATIONS IN DOLLARS DUE TO CERTAIN FACTORS PERTINENT IN FARMERS' DECISION-MAKING PROCESS
(Based on Table 5)

Group Variable	Specific Variable	Feeder Cattle	Slaughter Cattle
Class	Bull	+0.26	-2.10
	Cow	-4.61	-4.56
	Steer	+1.85	+3.28
	Heifer	-0.50	+0.26
	Calf	+3.01	+3.12
Weight (in lbs.)	< 300	+2.85	+3.61
	300-499	+0.44	+0.94
	500-699	-0.36	-0.96
	700-999	-0.67	-0.66
	1000 +	-2.36	-3.03
Buyer	Farmer	+0.29	-0.72
	Feedlot Operator	+0.29	+0.70
	Dealer	-0.17	-1.18
	Order Buyer	+0.70	+1.03
	Packer Buyer	-1.01	+0.18
Condition	Full	-0.38	-0.77
	Medium	0.00	+0.67
	Empty	+0.37	+0.10
Grade	Choice	+1.71	+4.79
	Good	-	+1.04
	Medium	+0.10	+0.95
	Plain	-1.81	-1.75
	Overfat	-	-2.30
	Boner	-	-2.91
Horns	Present	-0.45	-0.55
	Absent	+0.45	+0.55
Market	Auction	0.00	-1.15
	Terminal	0.00	+1.15

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